An Integrated Global CNS System

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Need for Next Generation CNS

- Urgent need for advanced CNS system that will allow greater traffic in and out of airports.
- Such a system is needed now, not in 2015 or 2020, or we will be facing unacceptable delays in air travel shortly.
- Now recognized that augmented GPS, with our current 60 year-old ground systems as backup, will never have the capabilities needed by aviation in decades to come.
- Joint Planning and Development Office in FAA still has no concept of the type of system needed.

System Architectural Requirements
needed for next air transportation system

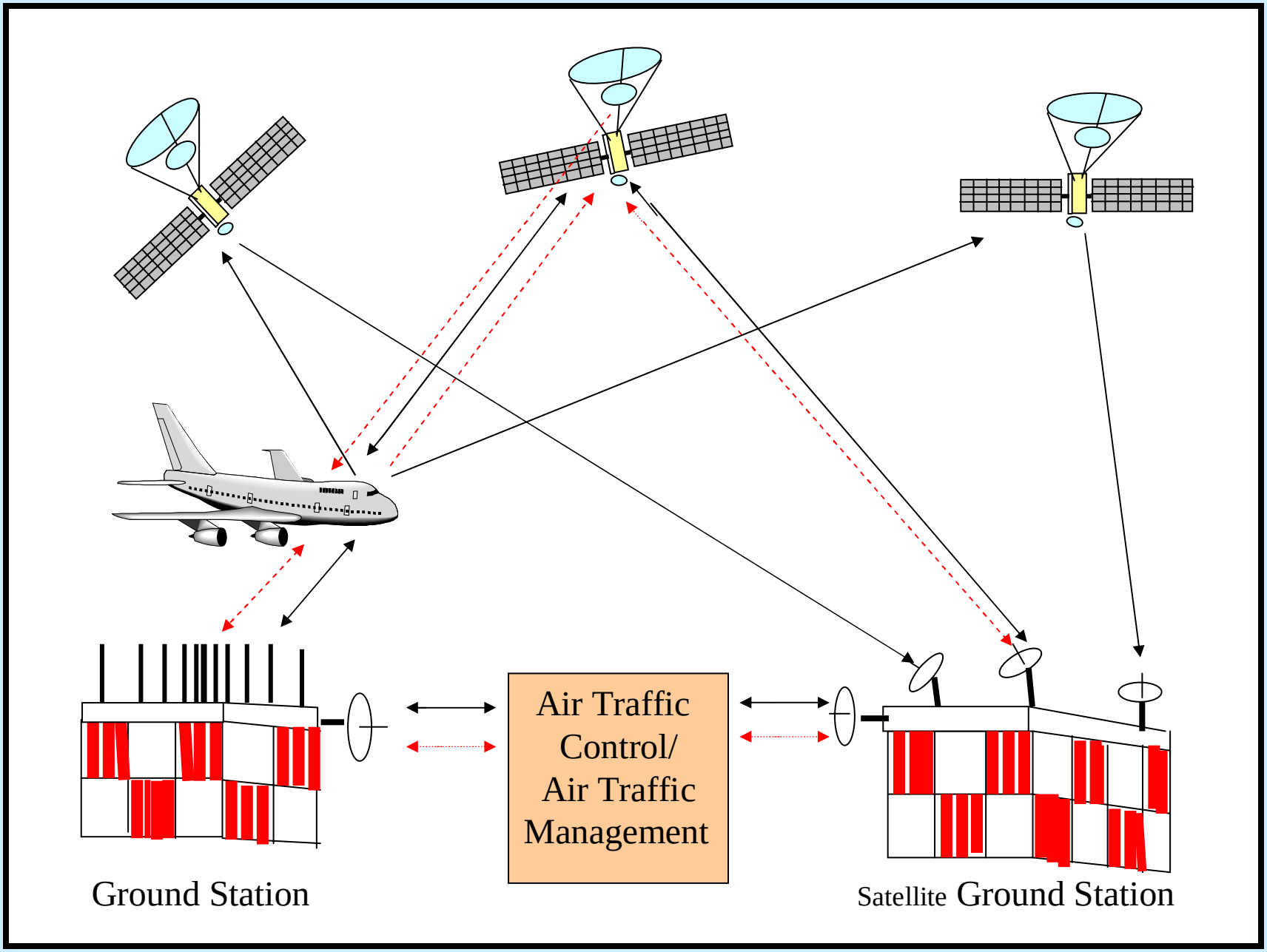
- A satellite system to provide global coverage.
- An integrated ground-based network of facilities to redundantly provide all CNS functions.
- The ground-based subsystem to provide Category III multi-runway landing guidance for *all* aircraft.
- A two-way system is needed for communications, surveillance and other functions.
- Adequate frequency spectrum for all CNS functions.
- An integrated digital system for all functions at minimum cost.

Next Generation Global CNS System

- Meets all of the system architectural require-ments with security and economy.
- Provides all civil (and military) CNS and other functions needed.
- Called the *Integrated Global Surveillance and Guidance System* (IGSAGS).

IGSAGS Functions

- Global precise 3-D aircraft positions for ATC surveillance, including airport surface.
- Global precise 3-D area navigation, pilot selectable.
- Global precise 3-D positions from and to *all* aircraft in area for collision warning/avoidance.
- Category I landing guidance globally.
- Global high-speed 2-way data link.
- Some 2000 global and land-based communication channels for digital voice/data.
- Redundant ground-based functions with, at airports, Category III landing guidance for *all* aircraft.



IGSAGS Aircraft, Satellite and Ground Station Intercommunications

Aircraft Position Determination and Data Linking at Heart of IGSAGS

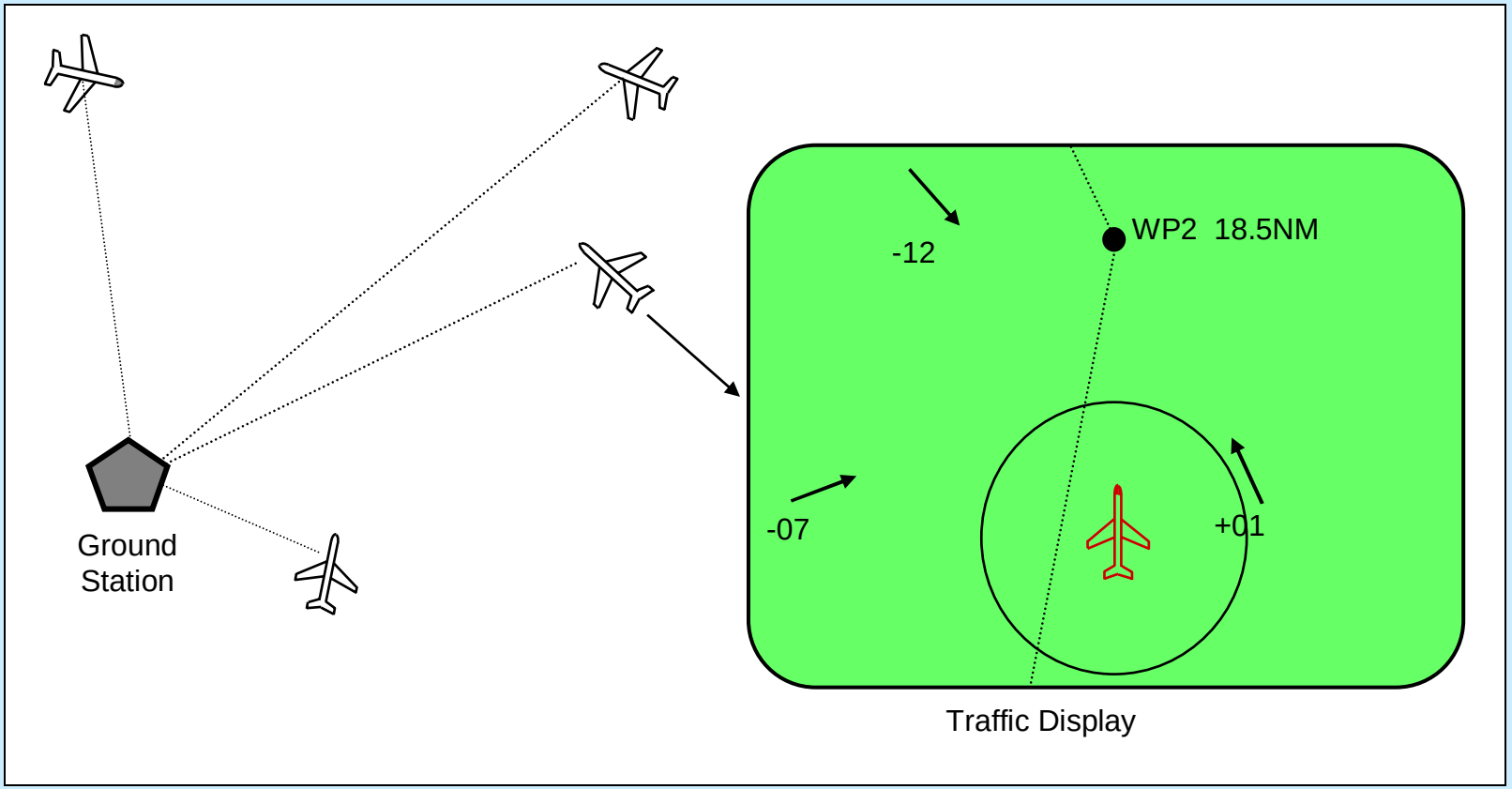
- Satellite ground facility transmits discretely addressed interrogation pulse to satellite, which it repeats to aircraft. The aircraft reply is received by 3 or more satellites, which repeat to the ground facility. Precise time delays from satellites of known position enables 3-D position of aircraft to be computed.
- The ground network facility interrogates the aircraft, and its reply delay determines the distance. Measurement of the reply's incident angle by an interferometer antenna array determines the azimuth angle, and with reported altitude, its 3-D position.

IGSAGS Surveillance and Navigation

- The satellite or ground-based subsystems 3-D aircraft positions are provided in latitude, longitude and altitude. These are used directly for ATC surveillance, including airport ground surveillance.
- The position data becomes part of the next interrogation to the aircraft for navigation purposes. It can be in other forms, such as to a waypoint, that the pilot can select. Such data reports are also used for landing guidance and collision warning.

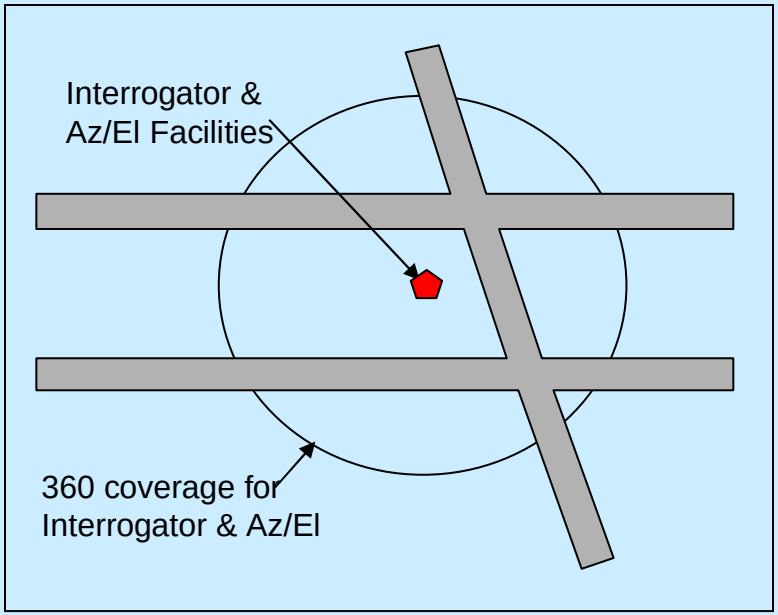
Collision Warning and Navigation Display

- All aircraft in vicinity receive lat/long and altitude from others.
- Relative positions of other A/C provide necessary data for a traffic environment and navigation display.



IGSAGS Landing Guidance

- Azimuth and elevation equipment can be placed at any location with respect to the runway, with offsets applied before transmission to the aircraft.
- This allows multi-runway guidance with a single set of equipment, each runway with a discrete identity code.



Landing Guidance (continued)

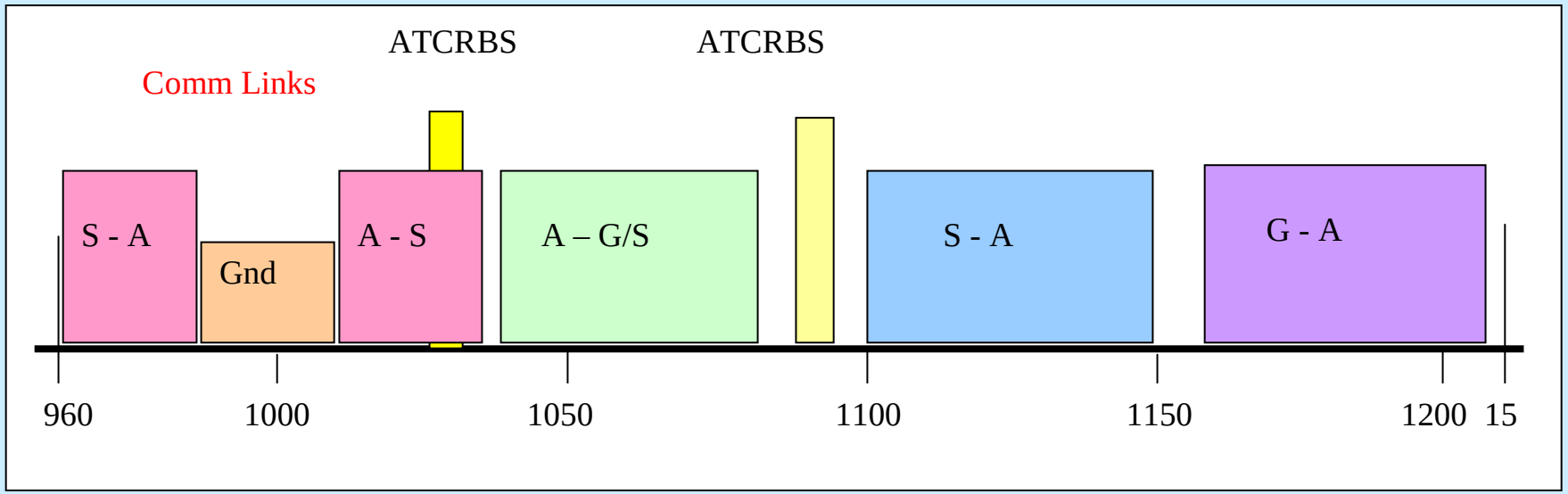
- Known distances from each reply pulse permits interferometer arrays to focus on aircraft enabling precise vertical and horizontal measurements.
- Measurements can be made on rise of reply pulse, eliminating reflected paths greater than 3 feet.
- Lineal rather than angular deviations near runway.
- Interrogations changed from 3 to 50/sec. on final.
- Shifted or steeper glideslopes can be provided.
- Category III guidance for *all* aircraft types provided through flare and touchdown.
- Moving map display provided showing any nearby parallel runway traffic.

Communications and Data Link

- Some 2000 25 KHz channels between satellite and ground subsystems provides digital voice or data communications. Also available for aviation internet, network centric or IP operations.
- Global or ground-based high speed (4 MB) data link available for clearances, airport conditions, weather, airport traffic views and a variety of other uses.

IGSAGS Spectrum & Aircraft Links in DME Band

- Uses TACAN/DME band with spread spectrum overlay, proved practical with JTIDS. Spread spectrum provides facility identification.
- Each aircraft/satellite/ground link 50 MHz wide except communications bands. Provides all CNS functions.

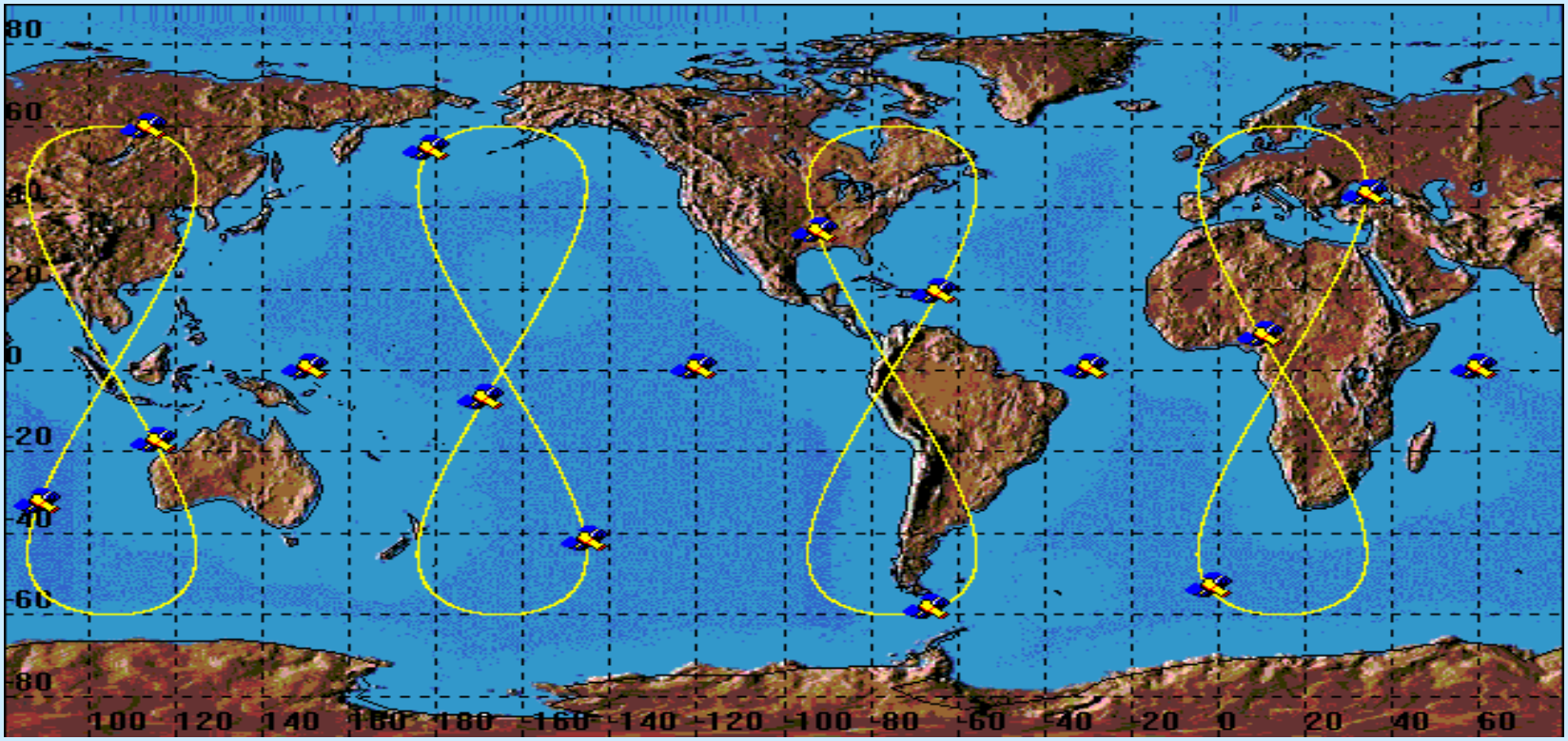


IGSAGS Satellite Subsystem

- 16 satellite constellation

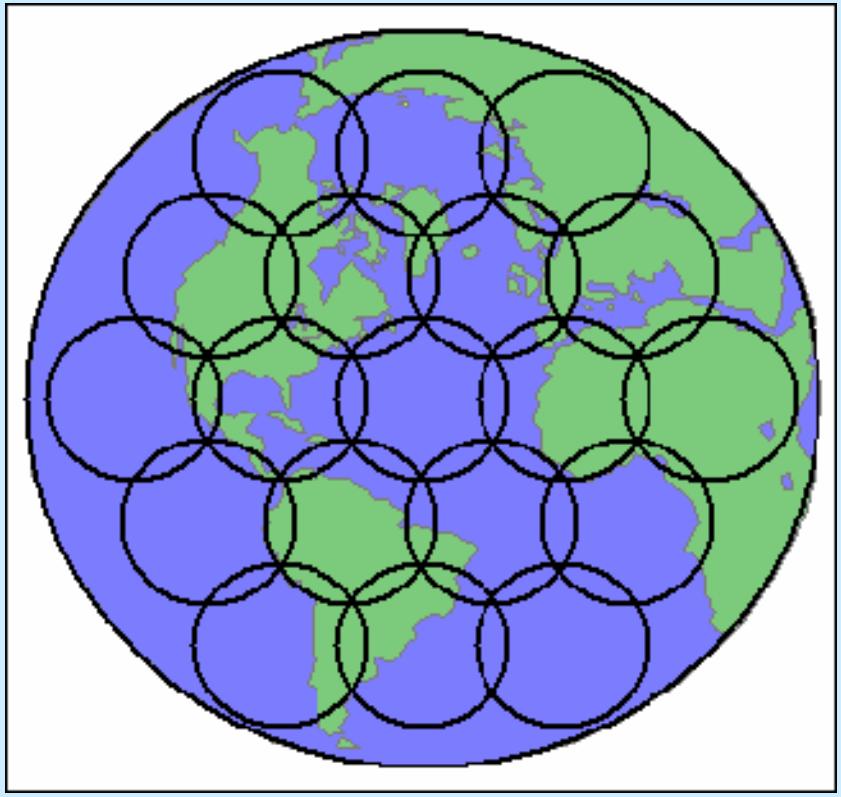
  - 4 geostationary, 4 60º geo-polar orbits each with 3 satellites

- Ground facilities for communications with satellites (3 in US)



19 Beam Coverage of Earth

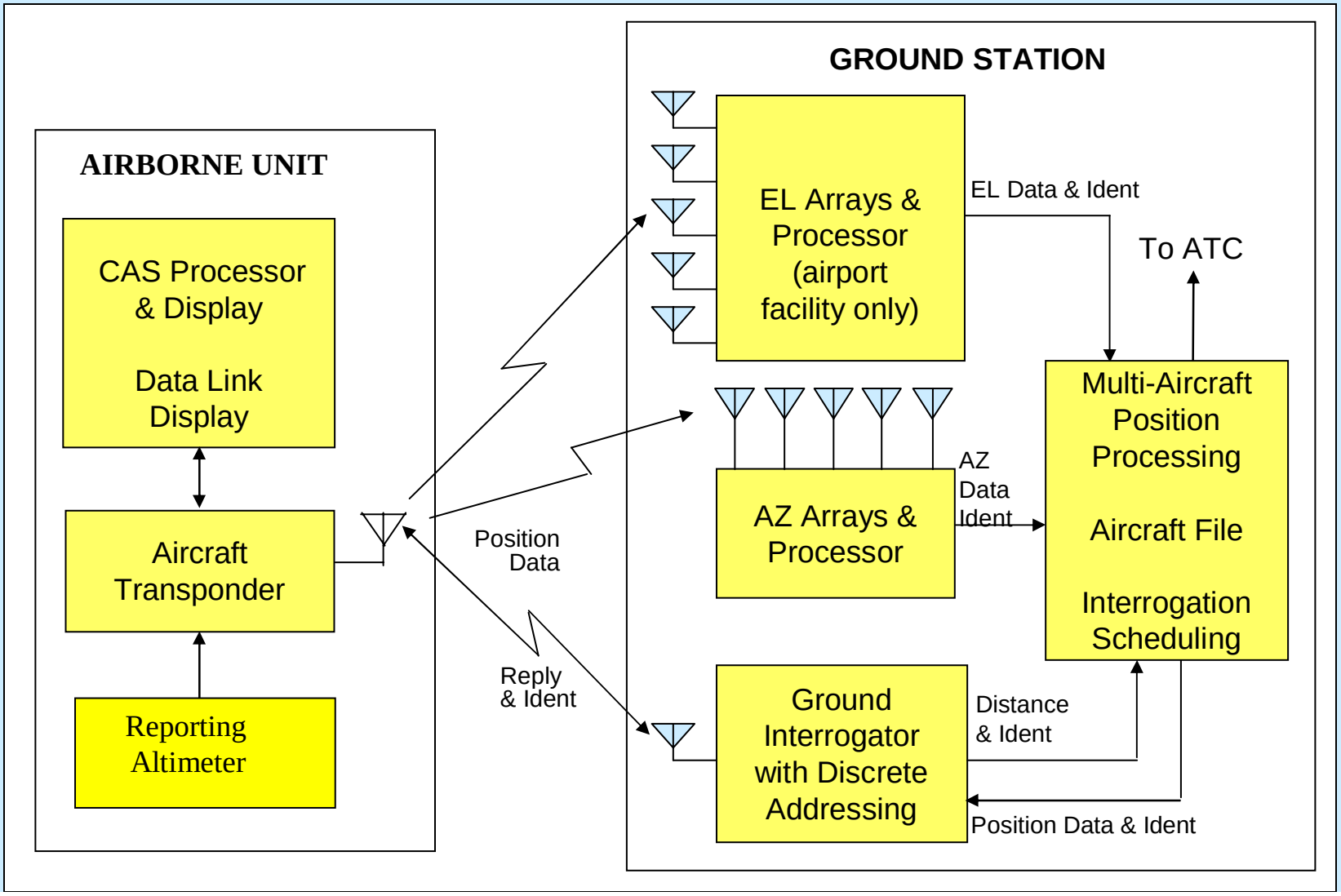
- 19 feed horns, each connected to a transponder, direct a matrix of beams toward a large reflector to produce earth beams, typically each beam controlled by a ground station.
- Each beam can handle 5000 A/C at one interrogation/ sec.



Airborne and Ground-Based Facilities

- Far fewer ground network facilities will be needed with IGSAGS than the 2428 VOR/DME, ILS and ATCRBS facilities in the U.S. today.
- A result of IGSAGS multi-functions and coverage redundancy with satellite subsystem, some 200 IGSAGS facilities will readily cover the U.S., about 140 at airports with Category III landing guidance.
- The IGSAGS airborne unit is relatively simple and low cost, being primarily a transponder. A second unit for the global communications is also required.

Airborne & Terminal Area Block Diagram



Conclusions

- Development of a next generation CNS system needs to be started NOW, not in a few years as appears to be the case with the JPDO program.
- Traffic limitations that already exist at many major airports can primarily be solved with an advanced CNS system, implemented as quickly as possible.
- Such a system needs to meet the system architectural requirements previously listed.
- IGSAGS does meet these requirements, providing *all* aviation functions with security and economy.